

THE  
Construction and Use  
OF A  
New UNIVERSAL DIAL,  
As now made by  
*HEATH* and *WING*,  
MATHEMATICAL and OPTICAL  
INSTRUMENT MAKERS,  
Near EXETER EXCHANGE in the STRAND,  
LONDON.

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Constitution and

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HEWITT

Mathematical

Instrument

New York Exchange

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**T**HIS Machine consists of three principal Parts, the first whereof we call the Horizontal Plane, (Fig. I.) because in Practice it must be parallel to the Horizon. On this Plane are two Spirit Levels for adjusting the Instrument; and in it is fixed an iron Axis perpendicular thereto, which enters into the Edge of the second Part or meridional Plane. This Plane is made of two Pieces, the lowest whereof is called the Quadrant, because it contains  $\frac{1}{4}$  of a Circle divided into 90 Degrees. The other Piece is a Semicircle adjusted to the Quadrant, and turning in it by a Groove, for raising or depressing the Diameter of the Semicircle, which is called the Axis of the Instrument.

B

The



The Middle of the Axis is called the Centre, to which a Thread is occasionally fastened. The third Piece is a Circle divided into 24 equal Parts, which are the Hours. This Circle is put upon the meridional Plane, so that the Axis must be perpendicular to its Plane. One Face of the Circle is called the superior, and the other the inferior Plane.

*The Construction of this Machine.*

Draw the Line XAY for the Axis; and upon A (the Middle of the Axis) (Fig. II.) as a Centre, describe the Semicircle XaY. From A raise the Perpendicular AB equal to half the Axis; and from the Centre B sweep the Arch EAC, making AB the Radius. From A, on both Sides, set off AP and AG, each  $23\frac{1}{2}$  Degrees; thro' which, from the Centre B, draw the Lines BP and BG until they cut the Axis XY in I and R. Then, upon the Centre A, with the Radius AR, describe the Circle ROIS; and divide its Periphery into 12 equal Parts, beginning at R: And thro' the Divisions draw parallel Lines to the Perpendicular SAB, on which the Signs are to be marked, as in the Figure. For drawing the Months, take the Sun's Declination for as many Days of them as you think proper to inscribe upon the Axis; and from A, upon the Arch AG and



and A P set off the Sun's Declination, making Points, thro' which from the Centre B, draw right Lines to the Axis; which Lines will cut the Axis in the Points where the Days of the Months are to be inserted. Let the Months be placed upon the Axis as in Fig. I. and the Signs marked below them on the Semicircle.

Immediately below the Axis may be marked the Degrees which serve to describe the Almicanter upon the Dial, in this Manner, *viz.* divide the Quadrant A C into 90 Degrees, thro' each of which from the Centre draw the Lines B C, B C, &c. cutting the Axis in the Points H, H, &c. whereto set the Figures 10, 20, 30, &c. with their Subdivisions, upon the Scale L L; upon which you can have the Degrees to 45. For the rest of the Degrees take B N equal  $\frac{1}{4}$  of A B, and draw N Z parallel to B \* C, (which will be parallel to the Axis X Y) then transpose the Distances N Q, N O, N E and N D unto the Scale M M, by drawing the Lines Q L, O L, E L and D L, each parallel to A B; by which you may have the Divisions to 70 Degrees, and further. It were not amiss to lay down these small Degrees on the oriental Side of the Semicircle, and the large ones on the occidental Side.

*The Use of this Machine.*

1. To describe a Dial on any Surface you please, whether rough or plain.

Place a Table near the Wall, (see Fig. III.) or any other Surface where you design your Dial; keeping as far between the Table and Wall as you design for the length of your Stile. On this Table place the Instrument, so that the horizontal Plane may be level. Put the Semicircle into the Quadrant, so that the Line of  $r$  and  $\perp$  may point at the Degree of the Pole's Elevation on the Quadrant: Then place the Circle on the meridional Plane, so that one of its Surfaces may touch the Centre of the Semicircle, and the Line of  $r$  and  $\perp$  without covering it. Turn (upon the iron Axis) the whole meridional Plane with its Circle in the Sunshine, till the Shadow of the Circle falls precisely upon the Day of the Month on the Axis, answering to the time of your Operation; taking great care that the Instrument be set truly level: Then will the Instrument be rectified for use.

Extend the Thread along the Axis from the Centre, till it meets with the Wall or other Surface on which you design to describe

### III. *To mark the Azimuths and Almicanter.*

In order to mark the Azimuths, the circular Plate of the Instrument (which represented the Equinoctial in the former Operations) must have a Circle divided into 32 equal Parts, either within or without that of the Hours. This suppos'd, leave the Quadrant in its former Situation, and turn the Semicircle in its Groove till the Axis be perpendicular to the Horizon; then apply the circular Plate to any Part you please of the Axis, provided it stand at right Angles to it: And stretching the Thread from the Centre till it touch that Plate in as many of the 32 Divisions as can be transferred to the Wall or Surface, the Thread for each Division will mark a Point on the Wall; which Points will be in the respective Azimuth Lines on the Dial Plane. Then shift the Circle to some other Point on the Axis, and proceed as before, to find a new Set of Points, and by straight Lines (continued as far as needful) connect every two Points belonging to the same Azimuth.

*N. B.* In this Operation the Vertex of the Stile must touch some Point of the Axis.

C

To



To mark the Almicanter place the circular Plate upon one of those Degrees which are marked on the Scale L. (Fig. II.) For Example on 10 Degrees: Then stretch the Thread, making it pass round the Limb, and it will describe the Almicanter in the same Manner on the Plane, as you were taught above to describe the Curve Line of any Sign. Removing the said Plate to the other Divisions on the Scale, describe the Rest of the Almicanter in the above Manner, and this way you may have them all to 45 Degrees; but for the Rest you must have another Plate, whose Radius is equal to  $\frac{1}{4}$  of the former, which must likewise have a Notch to let it slide upon the Semicircle, and putting this little Plate on the small Scale M, you may mark out the Almicanter to 70 Degrees and upwards, which is higher than the Sun's Meridian Altitude in any Place of *Europe*.

N. B. The Apex of the Stile in this Operation must coincide with the Centre of the Instrument.

#### IV. *To make a Dial by Reflexion on the Cieling of a Room.*

Place the Instrument in a Window (being rectified as formerly taught) till you find the Meridian in the Room, which will be when the Sun shining over the Limb of the Circle the Shadow of the Limb falls precisely on the Day of the Month upon the Axis; for then the Axis of the Semicircle will be parallel to the Axis of the World, and the Circle parallel to the Equinoctial. Then turn the meridional Plane with its Circle until the elevated Pole point directly South, and proceed in the same Manner as in the Construction of direct Sun-Dials. If you are only to draw the Hour Lines, the Piece of Mirrour (which is to indicate the Hours by a Speck of Light) is to be placed horizontally, so that the Middle of it may touch the Axis, or some Thread stretched along the Axis. But if you are to describe the Signs or other Lines thereupon, the Mirrour (placed horizontally) must be precisely at the Centre of the Instrument. Instead of a Piece of Mirrour, a small Vessel with as much Water in it as will raise the Surface to the proper Point where the Reflexion is to be made, may be used, because the Surface of the Water will be always horizontal.

V. *To find the Hour of the Day in any Place where the Sun shines.*

It is plain, that if you rectify the Instrument as above taught till the Shadow of the Circle falls upon the Day of the Month, the Axis of the Semicircle will cast a Shadow upon the Hour of the Day, on the upper Surface of the Circle, from the Twenty-first of *March* to the Twenty-third of *September*, and from thence to the Twenty-first of *March*, the Hour will be determined by the Shadow of the Semicircle upon the under Surface of the Circle.

*Remark.* In the foregoing Practices, it has been sometimes said that the Vertex of the Stile must touch the Centre of the Instrument, which in many Cases looks impracticable; but the Difficulty may be easily removed, if before you enter upon the Delineation of your Dial you fix a Stile in some convenient Place upon the Dial Plane, which Stile is to be made of two Pieces, the one to screw off and on the other: For having screwed together the Stile, and taken the Semicircle out of the Quadrant, apply the Rest of the Instrument, so that the Quadrant being upon the Plane of the Meridian, the  
Vertex



scribe your Dial; whether it be upwards towards the elevated Pole, or downwards pointing to an horizontal Surface, or even to a Wall which faces the North; the Point of the Surface touched by the extended Thread will be the Centre of the Dial, where all the Hour Lines must meet; whether that Point fall within the Space you design for your Dial, or run beyond it (which may be often the Case). Moreover the Thread thus stretched will give you the precise Situation of the Axis of your Gnomon, as any Point of it will give you the precise Place of the Apex of the Stile. For if you fix an iron Rod in the Wall as E D; in the same Point where the Thread touches it at D and in the same Situation with the Thread, that Iron will be a Gnomon, and its Shadow will coincide the whole way with the Hour Lines. But if the Thread run too far along the Wall, it would be impracticable to make so long a Gnomon of Iron; and in this Case it is sufficient to fix up a Stile, the Point whereof may touch the Thread in any Place; you may give to this Stile the Figure of a Bird or Serpent; if you cause the Beak or Tongue to touch the Thread, the Shadow thereof will mark the Hour of the Day.

There are several Methods of tracing or making the Hour Lines. As first, having rectified the Instrument, and stretched the  
Thread

Thread from the Centre, and fixed it to the Place designed for the Centre of your Dial, stretch another successively from every Hour of the Circle, (making that Thread touch the one stretched from the Centre of the Instrument) till it touch the Dial Plane, and it will mark Points on the Plane: Join these Points and the Centre of the Dial by straight Lines, and your Hour Lines are described. But if the Centre be too far upon the Wall, or cannot be found at all upon it, you must use the following Method.

Having placed the Instrument as above, take another Thread and tie it to the End of the Axis, making it pass thro' some Hour on the Circle as C: Then stretch it to the Wall so as it may touch some Point of the Axis or Thread, as at B: The Point G, where it terminates on the Wall or Plane, is in the Hour Line. From the same Hour C (in the Circle) stretch the Thread thro' some other Point of the Axis or Thread stretched from the Centre as F, and on the Surface mark the Point E where it terminates: The Point E is likewise in the same Hour Line. Then thro' both Points C and E, draw the Hour Line as far as needful; after the same Method are the Rest of the Hour Lines drawn.

A third Method is to be practis'd in a calm Night. Fix a Candle in such a Situation,

tion, that the Shadow of the Axis may fall on some Hour of the Circle, and the Shadow of the Thread stretched from the Centre of the Surface or Plane, this Shadow (being the Hour Line of the Dial) may be traced with a Pencil, and finished at your Leisure. After the same Manner you may trace out and finish all the Rest of the Hour Lines.

A fourth Method is to be practis'd in clear Sunshine, by Means of a Mirror situated so that it may throw the Shadow of the Axis on some Hour of the Circle; for then the Shadow of the Thread will mark that Hour on the Surface, &c.

## II. *To inscribe the Signs of the Zodiack on the above Dial.*

The Instrument continuing in its former Situation, stretch the Centre Thread along the Surface of the Circle: All the Points of the Wall where the extended Thread touches, are in the Equinoctial Line, which is to be drawn thro' these Points, and marked with  $\gamma$  and  $\alpha$ . Then transpose the Circle, and cause it to stand at right Angles to the Semicircle on the Sign  $\odot$ , putting it as far upon the Semicircle as the Notch will permit, then extend the



the Thread from the Centre of the Semicircle, till it touch the Limb of the Circle; and making it pass round the Periphery of the Circle, it will describe the Line of  $\infty$  upon the Wall or Surface. In like Manner, setting the Circle to all the other Signs on the Semicircle, mark them by the Thread upon the Dial Plane.

*N. B.* 1<sup>st</sup>, The Centre H of the Instrument (in this Operation) must be precisely in the Point where the Vertex of the Stile or Gnomon falls: And therefore must be much higher than it is represented in the Figure.

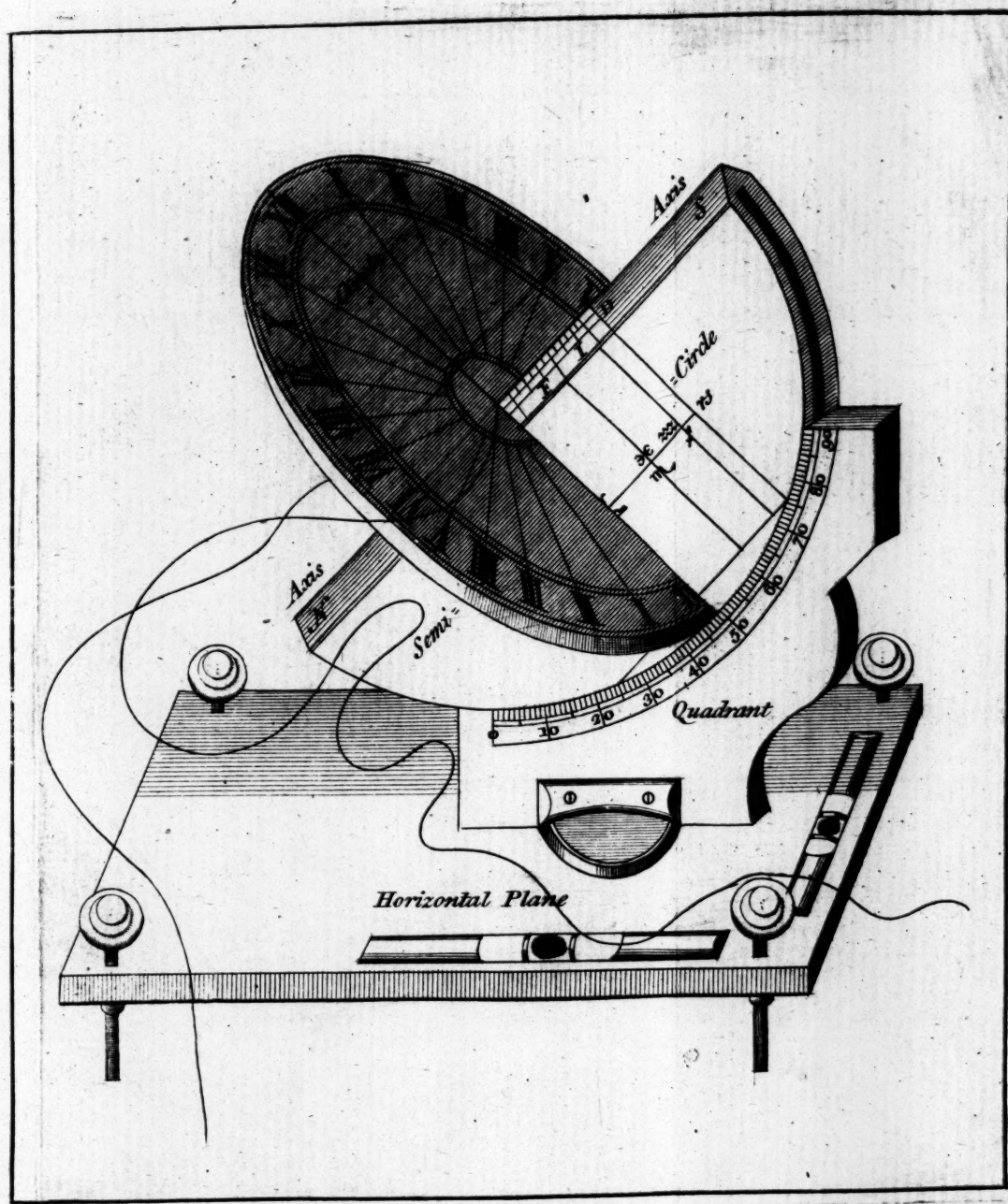
*N. B.* 2<sup>dly</sup>, To trace the Lines on the Dial Plane, you may provide a fork'd Bodkin (as G) between the Grains of which, the Thread (being stretched by a Weight of Lead) may slide while you move it upon the Dial Plane, and by making it touch the Centre Thread, or the Limb of the Circle, that you can rightly conduct it upon the Dial Plane, so as to trace out the Hour Lines: And when the Signs are drawn upon the Dial, the Stile will be found long enough, if it only reaches from D to K.

( 13 )

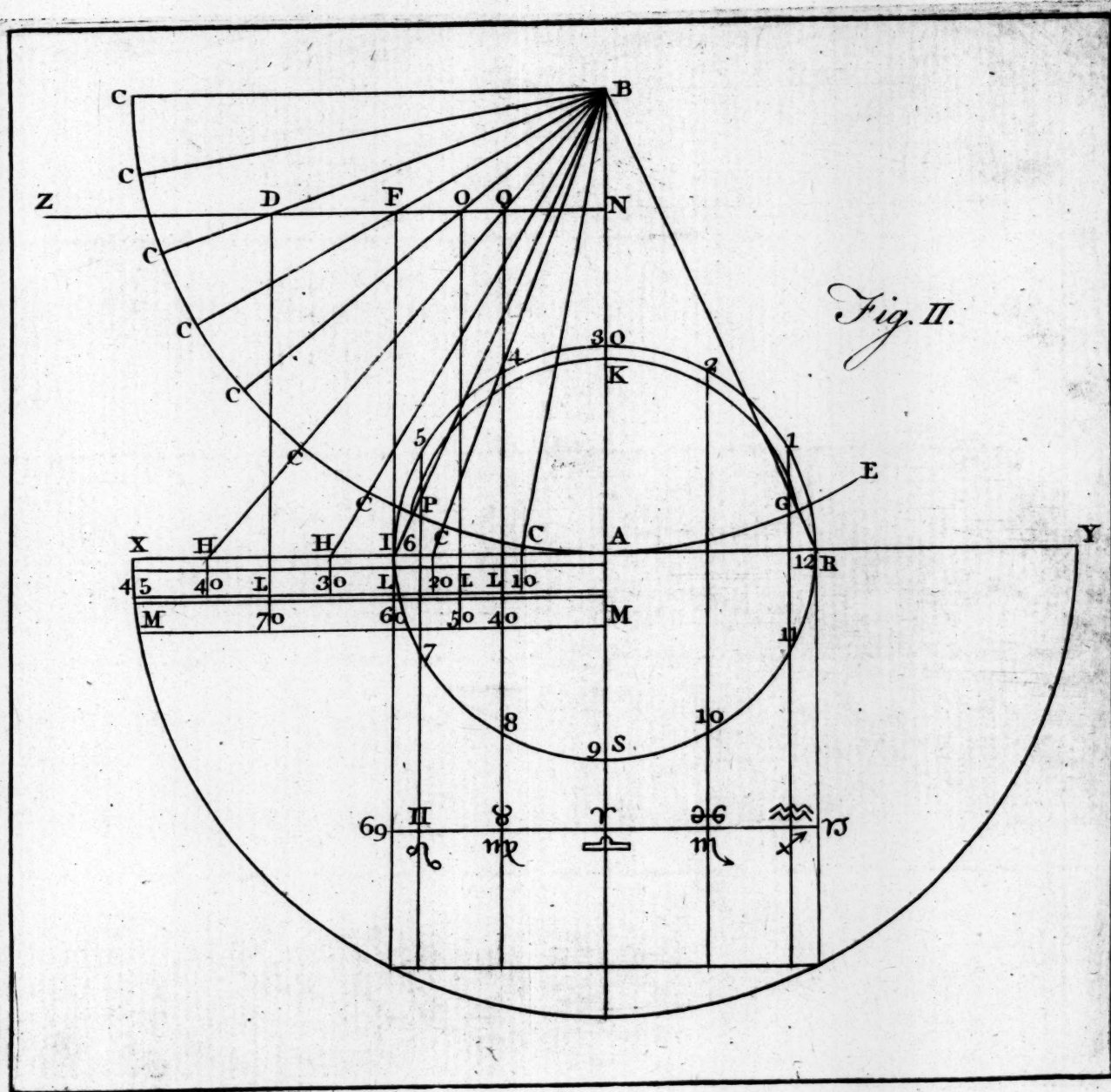
Vertex of the Stile may fall into its Centre ;  
then unscrew the Top of the Stile, rectify  
the Instrument, draw the Hour Lines according  
to the foregoing Directions, remove  
the Instrument, screw on the Top of the  
Stile, and your Dial will be finished.

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*F I N I S.*







*Fig. III.*

